BEEF COW NUTRITION AND REPRODUCTION EFFICIENCY

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by

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Pounds of calf weaned per cow carried is a good measurement of productivity of a cow calf operation. If this calculation is based on the number of cows exposed to the breeding program, then breeding efficiency is included in the measurement. But, if the cow count is taken as number of cows maintained through winter, the calculation may not include breeding efficiency, particularly if non pregnant cows were culled out in the fall. For our purposes, number of cows carried will be considered as the number exposed to the breeding program.

Reproduction efficiency including the percentage of cows having calves and the birth dates of these calves together with calf survival to weaning can effect herd output more than anything else.

This concept is illustrated as follows:

Table 1

Effect of Age of Calf and Calf Crop on Pounds of Calf Weaned Per Cow Bred

% Calf Crop	1st 20 days of calving Average age at weaning 200 days	2nd 20 days of calving Average age at weaning 180 days	3rd 20 days of calving Average Age at weaning 160 days	4th 20 days of calving Average age at weaning 140 days
100	450	412	374	336
90	405	371	337	302
80	360	330	299	269
70	315	288	263	235
60	270	247	224	202

For illustration, a 100 cow herd will be considered and the following assumptions made:

a) 70% heat detection in 20 days,

b) 65% of the cows will drop calves to first service,

c) calf loss equals 5%.

Table 2 shows a breakdown of the outcome of these assumptions.

Table 2

	Period of Service				
	1st 20 Days	2nd 20 Days	3rd 20 Days	4th 20 Days	Total
No. of cows showing heat	70	38	21	11	
No. of cows calving	45	25	14	7	91
No. of calves weaned	42	24	13	6	85
Av. weaning wt. - lb.	450	412	374	336	
Total lb. calf weaned	18900	9888	4862	2016	36666

Av. Weaning Weight = 367 lb. per cow carried.

For this example, the average weaning weight for calves from all cows is 83 lb. below the average weaning weight for those cows that calved out the first 20 days. Therefore, anything that can be done to increase the percentage of calves weaned and to increase the concentration of calf crop over time should pay high dividends.

Reproduction efficiency depends on:

a) percentage of cows eligible to breed (i.e. have calved out in time) for the early part of the breeding season,

b) the percentage of cows that come into estrus,

c) the percentage of cows that settle to first service and subsequently have calves, and

d) the percentage of calf survival to weaning.

These components are multiplicative to give final percentage of calves weaned for a given time period.

Referring back to Table 2, percentage of cows showing heat over the first 20 days was assumed to be 70%, settling rate 65%, and calf survival 95%.

.70 x .65 x .95 = 43% of calves weaned over a 20 day period

Y = A x B x C when Y = % calves weaned over a 20 day period,
A = % cows showing estrus over a 20 day period,
B = % cows calving to services of A,
C = % calf survival.

Table 3

Y =	A	x	B	x	C
.43	.70		.65		.95
.35	.65		.60		.90
.33	.70		.50		.95
.31	.50		.65		.95
.39	.70		.65		.85
.52	.80		.70		.95

Factors Affecting A, B, and C

A - Percentage of cows coming into heat over a concentrated period of time can be influenced by the concentration of the previous calf crop, nutritional level of the herd, disease factors and, if the program involves artificial insemination, proficiency in heat detection.

B - The fertility level of the herd will depend upon:

a) disease situation,

b) nutritional level of the herd, time interval from calving to breeding,

c) fertility level of bulls,

d) breed, and

e) artificial insemination - fertility level of semen used and proficiency of technician.

C - Calf survival:

a) about 50% of all calf losses occur within 24 hours of calving and from 70 - 80% of all calf losses occur within 72 hours of calving. The largest percentage of difficulty is with first calf heifers.

b) calf survival is influenced by:

i) Breed - crossbreds tend to have a higher survival rate than straightbreds,

ii) Age and size of cow at calving,

iii) Size of calf - medium sized calves tend to have a higher survival rate than either small or large calves. Size of calf is influenced by breed, length of gestation period, and feeding level. Cows that are fed heavily, particularly during the last three months before calving will tend to have calves somewhat heavier - this could be about a 5 lb. difference. The extra size of calf could add to calving difficulties with cows approaching a critical calving situation. Also, fat cows may have more trouble calving.

iv) Nutritional level and nutritional balance of cow herd,

v) Disease factors,

vi) Environment,

vii) Facilities for calving, and

viii) Care at calving time.

The purpose of this paper is to discuss the nutrition of the beef cow and the relationship of nutrition to reproduction. Other factors mentioned above have been dealt with in some detail elsewhere, Jeffery (1969) and Jeffery (1970).

Beef Cow Nutrition as Related to Reproduction Efficiency

Cow-calf studies of the Economics Division, A.D.A. (1967), indicates that 60% of total costs of a cow-calf enterprise was attributable to costs of feed. It is, therefore, important to strive for a low cost ration, supplied in sufficient quantity to adequately meet the cows needs without feeding in

excess of requirements.

One of the first indicators of inadequate nutrition is lowered reproduction efficiency:

a) Cows that lose excessive weight over winter tend to be slow in showing heat after calving,

b) Cows that fail to gain weight or perhaps lose weight from calving until the breeding season tend to be low in fertility,

c) Underfed heifers tend to be late in developing sexual maturity and hence slow to show heat,

d) Reproduction may be adversely effected by a deficiency of any single essential nutrient. Adequate nutrition for satisfactory reproductive performance implies meeting the animals needs for energy, protein, minerals and vitamins.

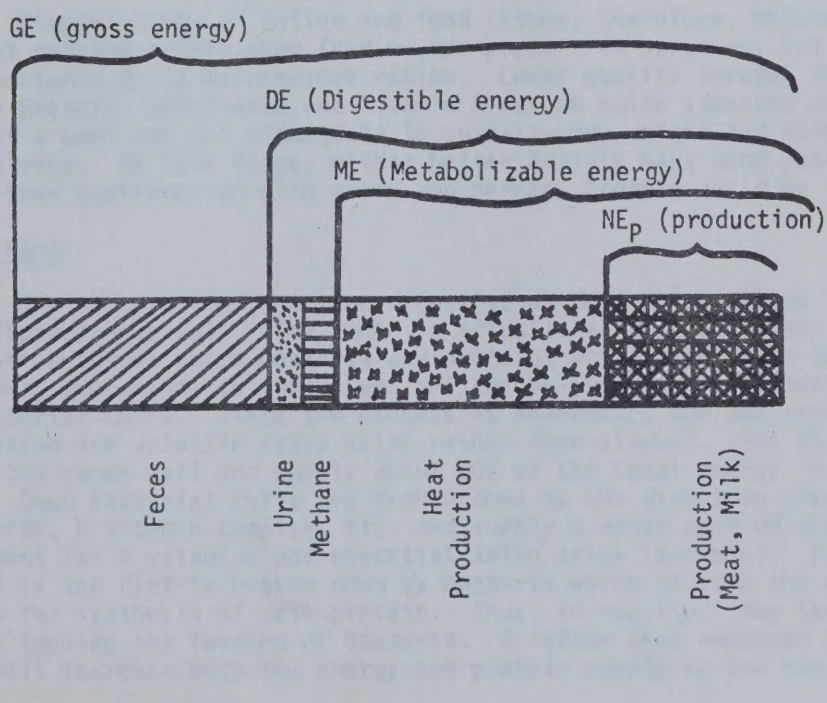
Energy and Protein

The terminology of energy and energetic efficiencies can be somewhat confusing. Terms one encounters include total digestible nutrients (TDN), gross energy (GE), digestible energy (DE), metabolizable energy (ME) and net energy (NE).

The following chart may help in clarifying the above terms.

Figure 1

Partitioning of Energy in a Feed



It can be seen from the above chart that a large proportion of total feed intake of an animal is lost through the feces and by heat of digestion and metabolic processes. The proportion of feed lost in the feces increases with increased fibre content of feed. Digestibility of milk is approximately 90%, grain about 70%, early cut hay 55%, mature hay 45 to 50%, and straw 35 to 45% (Table 4).

A maintenance ration may be defined as a ration that provides sufficient energy to satisfy the metabolic processes of the body,maintain body temperature and maintain body activity. With a maintenance ration, there is no change in body weight nor is there any net production. The efficiency of metabolizable energy for maintenance is generally relatively independent of the ration and is in the order of 70%. However, the net efficiency of ME for production (synthesis) varies depending upon composition of both feed and the end products of production. For example, efficiency for net synthesis of milk production may approach 70%, whereas net efficiency for body tissue synthesis may range from 30 to 60%. Efficiency of use of ME above maintenance is higher for grains than forages. The lower the quality of the forage, i.e. the greater the fibre content, the less value it has as a fattening ration which is attributable to higher fecal loss and lower efficiency in the use of metabolizable energy. The principle is shown in Figure 2 (page 6).

It will also be noted from Figure 2, that gross efficiency for production commonly referred to as feed conversion is highly dependent upon net food intake over maintenance requirement. Because of fixed maintenance costs, feed conversion of an animal gaining 3 lb. per day must be considerably more favorable than for an animal gaining only 1 lb. per day, however, there may be little difference between the two animals in net efficiency (i.e. conversion of energy above maintenance requirement to product).

Digestibility of ration and food intake, therefore, become extremely important considerations when feeding for productive purposes, but are of much less importance for a maintenance ration. Lower quality forages fortified with adequate protein, phosphorus and Vitamin A may be quite adequate as a maintenance ration of a beef cow but inadequate to sustain body weight and milk production after calving. At this stage, either better quality hay, good pasture or low quality feed supplemented with grain and perhaps protein would be indicated.

The Ruminant

The ruminant has a unique digestive process which allows it to utilize highly fibrous materials. The rumen is actually a large anaerobic (no air) fermentation vat in which bacteria and protozoa utilize the feed taken in by the animal; the animal in turn lives off the by-products of fermentation and dead bacterial cells. Since the process is anaerobic, the end products of fermentation are volatile fatty acids rather than alcohol. The VFA are absorbed through the rumen wall and supply about 80% of the total energy intake of the animal. Dead bacterial cells are broken down by the digestive processes into amino acids, B vitamin Complex, etc. and supply a major part of the animal's requirement for B vitamins and essential amino acids (protein). Protein supplied in the diet is broken down by bacteria which utilize the nitrogen fraction for synthesis of cell protein. Thus, in reality, the feeding of a ruminant implies the feeding of bacteria. A ration that enhances bacterial growth will increase both the energy and protein supply to the host animal.

Figure 2

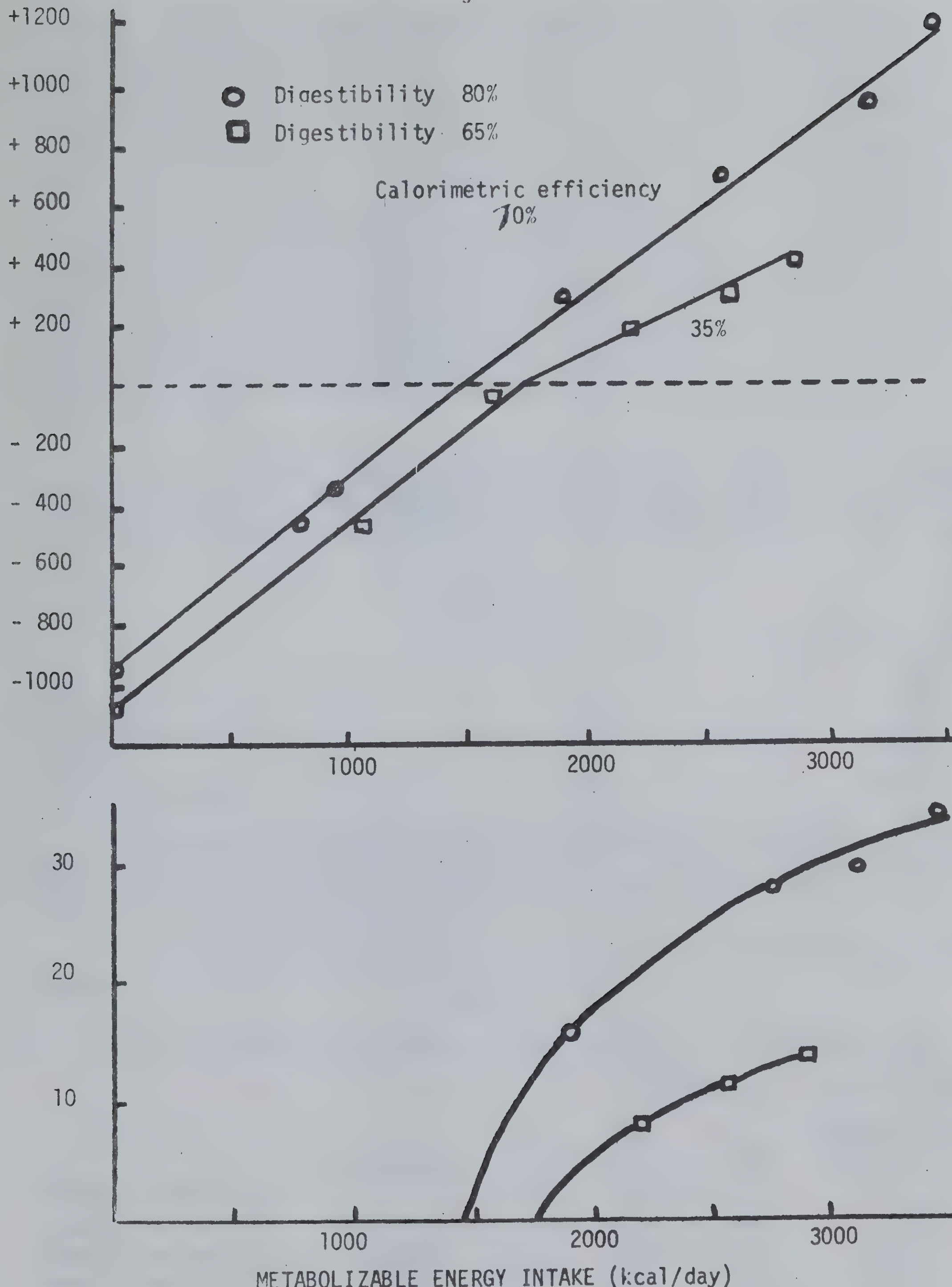


Figure 2 (a) Calorimetric efficiency of utilization of the Metabolizable Energy (ME) content of two rations fed above and below maintenance.
(b) Productive efficiency of conversion of ME into animal product.

Source: Webster (1970)

To obtain a growing dynamic bacterial population, it is necessary that sufficient nitrogen be available in the diet. If the diet consists of readily fermentable materials (grain, high in starch) some of this nitrogen can be supplied in the form of urea. However, urea rapidly dissipates as ammonia, and therefore is not a satisfactory source of nitrogen when animals are fed a high roughage diet - since the fermentation process of roughage is much slower. Therefore, nitrogen must be supplied in a slower releasing form such as protein. By maintaining an adequate protein level in the diet and hence a more dynamic population of microflora, better utilization can be made of low quality forages. For this reason, an animal will obtain more total energy from a given intake of straw when protein is adequate compared to when protein is deficient. It is also probable that the total intake of straw will be greater when adequately supplemented with protein. Further to this, when protein is adequate, because of a more dynamic microflora population, the host animal will obtain more protein and hence may make more efficient use of metabolic energy that is provided.

The utilization of crude protein by the animal varies considerably between feeds. Therefore, protein requirement should be based upon digestible protein contained in a feed rather than crude protein. The relationship of crude protein to digestible protein given in NRC tables (1970) are as follows:

Table 4

(NRC, 1970)

	% Crude Protein	% Digestible Protein
Brome hay	11.8	5.0
Alfalfa hay	15.9	11.4
Barley straw	4.1	0.5
Barley	9.8	5.6
Linseed oil meal	38.6	34.0

The protein compositions as listed above will, of course, vary depending upon area, conditions, maturity, etc. However, they do indicate the relative value of protein from different feeds, for example, the protein value in mature barley straw is almost negligible.

Protein and energy requirements for beef cows and heifers is given in Table 5.

Table 5

Protein and energy requirements of beef cows and heifers (NRC, 1970)

			Energy		Protein	
Class of Animal	Body Wt. lb.	Wt. Gain lb.	ME (Mcal)	TDN lb.	% Digestible of dry matter in ration	lb. Digestibl
Growing heifers	440	1.10	11.4	7.0	7.1	0.80
Growing heifers	660	1.10	16.9	10.3	6.1	1.10
Growing heifers	880	0.55	15.9	9.7	4.6	0.77
Dry Pregnant Cows	990	0	12.4	7.5	2.8	0.42
Dry Pregnant Cows	1100	0	13.6	8.4	2.8	0.47
Dry Pregnant Cows	1200	0	14.4	8.8	2.8	0.49
Cows Nursing Calves	990	0	20.4	12.3	5.4	1.17
Cows Nursing Calves	1100	0	21.6	13.2	5.4	1.25

It must be emphasized that the above recommendations are guidelines only, energy requirements of an animal will vary depending upon exercise and temperature.

Webster (1970) estimates the energy requirement of an 1,100 lb. cow on free range to be 16.2 M cal. compared to 10.9 M cal. for a cow that is housed. The 16.2 M cal. would be equivalent to 10 lb. of TDN. It is indicated by this worker that exercise alone increased the energy requirement by 48 per cent. The protein requirements given in Table 5 are minimum requirements and perhaps even on the low side. The 1966 NRC recommendations indicated 4.4% digestible protein of the ration for mature beef cows for maintenance. If the recommendation of minimum protein allowance is to be followed in interest of a low cost ration, digestible protein probably should be increased to 4% sixty days prior to calving to provide for tissue synthesis of the fetus and hence minimize tissue depletion of the cow.

Approximate digestibility estimates for several common feeds are given in Table 6.

Table 6

Approximate Digestibility Estimates of Common Feeds

Forages

Forages	TDN	Est. Daily Consumption Per 100 lb. body wt.	Grains	TDN
Good quality hay	50%	3 lb.	Oats	65%
Medium quality hay	45%	2 lb.	Barley	70%
Oat & Barley straw	40%	1 1/2 lb.	Wheat	75%
Wheat straw	30%	1 lb.		

By using tables 4, 5, and 6 as guides, an approximate ration can be calculated for beef cows. For purpose of illustrating a maintenance ration for a 1,000 lb. beef cow assuming an energy requirement of 9 lb. of TDN per day, the following examples are given:

Example 1 -	15 lb. of straw -	6 lb. TDN	.08 lb. Digestible Protein
	3 lb. of grain -	2 lb. TDN	.11 lb. Digestible Protein
	1 lb. 32% Supplement -	0.75 lb. TDN	.30 lb. Digestible Protein
Totals		8.75 lb. TDN	.49 lb. Digestible Protein
Example 2 -	10 lb. of straw -	4 lb. TDN	.05 lb. Digestible Protein
	7 lb. of grain -	5 lb. TDN	.39 lb. Digestible Protein
Totals		9 lb. TDN	.44 lb. Digestible Protein
Example 3 -	10 lb. of straw -	4 lb. TDN	.05 lb. Digestible Protein
	10 lb. of hay -	5 lb. TDN	.50 lb. Digestible Protein
Totals		9 lb. TDN	.55 lb. Digestible Protein

The above examples show 3 rations approximately balanced for energy and protein for maintenance of a 1,000 lb. beef cow. The choice between these rations would be determined by availability and cost of feed constituents, the objective being an adequate ration at minimum costs.

Similarly, rations can be calculated for the cow after calving where allowances for additional energy and protein have to be made for milk production and some weight gain. At this time, the energy requirement will increase by 50 to 60%, percent digestible protein will approximately double and total pounds of digestible protein required will increase by about 3 times. Low quality feeds which can be satisfactory for maintenance are of limited value after calving because of low digestibility and low intake. The poorer quality roughage should be fed during the maintenance period and the better quality roughage reserved for after calving. If high quality forage is used for a maintenance ration, restricted feeding and/or dilution with straw would be indicated.

Use of a Scale

Use of feeding standards for energy requirements of cattle is only an approximation. Because of the number of variables involved such as feed quality, size and activity of animal, and weather conditions, it is impossible to arrive by calculation at precise feeding recommendations. The best indicator of energy intake is weight change of animal. Periodic weighings will indicate whether or not the cow herd is maintaining weight, whether or not growing heifers are gaining sufficient weight and so on. Tabulation of body weight changes over monthly intervals is probably the best indicator as to whether or not a ration requires adjusting. There will also be individual differences in body weight change within a herd. Aggressive cows may be doing better than others, some of the older cows may be losing condition, etc. It may pay to separate out the poor doers from the main cow herd and feed them separately.

As a guideline, the following summary may be useful:

1. Mature cows should be fed to maintain body weight up to 3 months before calving and should gain about 100 lb. (weight of fetal growth, water, etc.) over the last 3 months of pregnancy. Following calving cows should be in a gaining situation until the end of the breeding season (1/2 to 3/4 lb./day).

2. To breed as yearlings, yearling heifer calves should be fed to gain 1 - 1 1/2 lb./day from weaning until breeding.

3. First and possibly second calf heifers should be maintained during the winter in separation from the main cow herd. They are growing animals and require a feed that is higher in digestibility and protein than mature cows. Better quality feed would be indicated.

Energy and Reproduction

Dr. J. N. Wiltbank (1970) has carried out extensive experiments at the University of Nebraska to determine the effects of varying levels of management and nutrition on reproductive performance. He concludes that low energy levels before calving where cows lose considerable body weight (adjusted for pregnancy) result in cows being slow to show heat after calving.

Table 7

Occurrence of post-calving estrus (heat) and conception rate of cows on two levels of energy prior to calving

Level of Feed: Before Calving lb. TDN	Level of Feed: After Calving lb. TDN	Days after Calving: 40	50	60	70	80	90	% Pregnant from 1st Service
		% which had shown heat						
		Older Cows						
9.0	16.0	-	65	80	90	90	95	67
4.5	16.0	-	25	45	70	80	85	65
		2 yr. Old Cows						
8.0	13.0	22	68	81	90	92	97	63
4.3	13.0	7	27	49	66	73	83	53
		2 yr. Old Cows						
8.0	13.0	21	38	71	92	96	100	50
4.3	13.0	13	30	52	70	83	91	56

Source: Wiltbank (1970)

As noted from Table 7, each group of cows on low levels of energy before calving were much slower to come into heat after calving, however, conception rates were apparently not affected. However, cows receiving adequate energy before calving but inadequate energy after calving tended to show heat normally but were low in fertility. This tendency is indicated in Table 8.

Table 8

Occurrence of estrus and conception rate in cows on two levels of energy post-calving

Level of Feed: Before Calving lb. TDN	Level of Feed: After Calving lb. TDN	Days after calving: 40	50	60	70	80	90	Pregnant 90 Days From 1st Service
		% which had shown heat						
		Older Cows						
9.0	16.0	-	65	80	90	90	95	67
9.0	8.0	-	76	81	86	86	86	42
		2 yr. Old Cows						
8.0	13.0	22	68	81	90	92	97	63
8.0	7.0	6	73	64	81	81	81	53
		2 yr. Old Cows						
8.0	13.0	21	38	71	92	96	100	50
8.0	7.0	23	85	92	92	96	92	37

Source: Wiltbank (1970)

Table 9 gives a comparison of results for post-calving heat manifestation and fertility between two groups of cows, one fed adequately before and after calving and the other on low energy levels before and after calving. As can be seen, breeding results both in respect to cows showing heat after calving and fertility were disastrous when cows were maintained on extremely low levels of energy before and after calving.

Table 9

Reproductive performance of cows on inadequate energy levels

Before Calving lb. TDN	After Calving lb.TDN	No.of Cows	Pregnant % 1st 20 days breeding	Pregnant % End of breeding season	Pregnant from first service
9.5	16	21	60	95	67
4.5	8	20	15	20	33

Source: Wiltbank (1970)

Similar relationships between low energy and reproduction performance have been reported by other workers.

Minerals and Vitamins

Beef cattle should be provided with a free choice source of a calcium-phosphorus mineral year around. A preferable mineral is one with a Ca-P ratio of 1:1 containing 15 to 20% phosphorus. Since forages generally are very low in phosphorus and high in calcium, it is important that cattle maintained on a high proportion of forage be provided adequate phosphorus.

Cows deficient in phosphorus frequently either do not come into heat, have irregular heat periods and may be low in fertility. Tables 10 and 11 give an indication of the seriousness of a phosphorus deficiency relative to reproduction performance.

Table 10

Effect of phosphorus on calf crop

	No Phosphorus	Bone Meal
No. of cows	168	168
Calf crop weaned (%)	64	88
Av. No. days between calving	459	365

Source: Wiltbank (1970)

Table 11

Effect of phosphorus supplementation on calf crop

	No. of Cows	Cows Calving	Cows Weaned Calves
Phosphorus supplement	143	85%	81%
No phosphorus supplement	40	64%	58%

Source: Texas - author unknown

A deficiency of Vitamin A results in a deterioration of mucous membranes which lowers the animal's resistance to infection. A Vitamin A deficiency is associated with pneumonia, blindness, scours, weak or dead calves, nerve degeneration, abortion and retained placentas (cows don't clean after calving). Beef cows should be provided with 40,000 International Units of Vitamin A per day from December up to two months prior to calving when dosage should be increased to 60,000 I.U. per day and maintained after calving until green grass. The only source of Vitamin A for the calf is from its mother's milk.

Management of Replacement Heifers

As indicated previously weaning weight of calf is highly associated with age of calf at weaning. A missed heat period can mean as much as 40 to 50 lb. in reduced weaning weight of calf. If the objective is high weaning weights, a concentrated early calving period is essential. Once cows calve late, it is extremely difficult to advance the calving date appreciably.

Table 12

Av. No. of days Calving to start of breeding	In heat 1st 20 days of breeding season		
	Cows 5 years or older	2 and 3 year old cows	Cows conceiving on first service
70	95%	79%	62%
50	88%	64%	58%
30	70%	32%	33%
10	29%	10%	33%

Source: Wiltbank (1970)

The above table points out that cows calving late don't have time to come into heat after calving to be bred soon enough to calve out over the first 20 days of the calving period. Cows bred too soon after calving have a lowered conception rate, since the uterus has not had time to return to normal. Cows should have 50 to 60 days reproductive rest following calving. The data in Table 12 clearly indicates that heifers were slower coming into heat after calving than mature cows. This is an important observation. Virgin heifers should be bred about 3 weeks earlier than the main cow herd. For satisfactory reproduction, heifers must be sexually mature. Sexual maturity is a function of both age and weight. This is indicated in Tables 13 and 14.

Table 13

Weight of Heifers	Percent in Heat		
	Hereford	Angus	A x H
450	-	-	-
500	-	8	-
550	-	44	18
600	27	72	43
650	50	84	68
700	62	88	78
750	88	100	93

Source: Wiltbank (1970)

Table 14

	Hereford			Angus			A x H		
Age in Months	13	14	15	13	14	15	13	14	15
Winter Gain					Percent in heat				
0.5 lb./day	4	22	41	33	57	77	41	75	91
1.0 lb./day	38	65	77	76	80	92	74	82	97
Difference (% in heat)	34	43	36	43	23	15	33	7	6

Source: Wiltbank (1970)

It would appear that breeding heifers should be at least 14 or 15 months of age at the start of the breeding season and weigh about 650 lb. Feeding requirements and desirable gain for virgin heifers has been mentioned. A word of caution: heifers should not be overfed during puberty, there is evidence to indicate that heavy feeding and excess fatness at time of puberty tends to displace milk secreting tissue with fat cells and hence permanently reduce the animal's potential for milk production.

For a successful early crop of calves from first calf heifers Wiltbank (1970) suggests breeding 50% more heifers than required for replacements, start the breeding program 3 weeks earlier than the main cow herd and discontinue breeding after 40 to 45 days.

<u>Summary</u>

The object of beef cow nutrition is to provide an adequate least cost ration that will provide all essential nutrients in sufficient quantity to maintain the health and welfare of the animal and sustain production and reproduction at a satisfactory level. Reproduction efficiency is essential to an economic cow calf operation. Nutrition is a major factor influencing reproduction efficiency.

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